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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:	Art Unit: 1722
Masanori KIMURA	Examiner: G. Nagesh Rao
Serial No: 10/030,867	
Filed: April 29, 2002	
For: METHOD FOR GROWING SEMICONDUCTOR SINGLE CRYSTAL	

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APPEAL BRIEF

Mail Stop APPEAL BRIEF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

This is an Appeal from the Examiner's Final Rejection of claims 1-5. The Final Rejection issued on December 27, 2005 and the Notice of Appeal was sent in the Patent and Trademark Office on March 23, 2006.

(i) REAL PARTY IN INTEREST

The real party in interest is Shin-etsu Handotai Co., Ltd., Tokyo, Japan.

(ii) RELATED APPEALS AND INTERFERENCES

None

(iii) STATUS OF CLAIMS

Claims 1-5 are pending. This Appeal is directed to the final rejection of claims 1-5.

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(iv) STATUS OF AMENDMENTS

This appeal is being filed in response to the final rejection of December 27, 2005. A separate response to the final rejection of December 27, 2005 has not been filed.

(v) SUMMARY OF CLAIMED SUBJECT MATTER

Claim 4

Claim 4 defines a method for growing a semiconductor single crystal according to the Czochralski method utilizing an apparatus (shown in Fig. 1) for producing a semiconductor single crystal 13 having a crucible 4, 5 to be charged with a raw material 12, a heater 2 surrounding the crucible 4, 5, pulling means 15, 16 for bringing a seed crystal 14 into contact with a melt 12 contained in the crucible 4, 5 and growing a single crystal 13 and a metal chamber 17 for accommodating the foregoing members. A crucible 4, 5 having an inner diameter of 28 inches or more (see lines 17-27 of page 13 of specification) is used, and the apparatus (Fig. 1) is provided with subsidiary heating means 9 below the crucible 4, 5. As described at line 20 of page 20 through line 17 of page 21 of the specification, and Example 3 which begins on page 27 of the specification, after a grown single crystal 13 is detached from the melt 12 and taken out from the apparatus for producing a crystal, a raw material is newly added to the raw material 12 remaining in the crucible 4, 5 and melted. When a seed crystal 14 is brought into contact with the melt 12 to pull a single crystal 13 again, the crucible 4, 5 is heated by the heater 2 surrounding the crucible 4, 5 and the subsidiary heating means 9 to prevent solidification of raw material melt at least for a period from the point of the detachment of the single crystal ingot 13 to the point of complete melting of the raw material 12 in the crucible 4, 5 including the raw material newly added thereto. The electric power supplied to the subsidiary heating means is increased when the raw material is newly added to the raw material melt remaining in the crucible.

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Claims 1-3 and 5

Claim 1 depends from claim 4, claims 2 and 3 each depend from claim 1, and claim 5 depends from claim 2.

(vi) THE GROUND OF REJECTIONS TO BE REVIEWED ON APPEAL

The ground of rejection to be reviewed on appeal is the rejection of claims 1-5 under 35 USC 103(a) as being unpatentable over US Patent 6,458,202 of Kojima in view of JP 01040668 of Ito, in further view of US Patent 6,156,119 of Hoshi and in further view of US Patent 6,562,125 of Schupp.

(vii) ARGUMENT

According to the Final Office Action of December 27, 2005, Kojima discloses most of the subject matter of the claims, but it does not describe utilizing a percentage of the bottom heater in terms of weight of the ingot withdrawn versus the original raw material weight. Also, heating of the raw material between pulling cycles is not detailed in Kojima. Ito is said to disclose a method for growing a semiconductor crystal by the Cz pulling method in which a quartz crucible is filled with raw material and heated to form a melt, side heaters and bottom heaters are used in the heating process, and a seed crystal is contacted with the melt and slowly pulled up to form a single crystal ingot. According to the Office Action, it would have been obvious to one of ordinary skill in the art at the time the invention was made to combine the raw material melting use of the bottom heater in Ito with the growth use of the bottom heater of Kojima, because turn around time between uses of the apparatus would have been reduced and more product could have been made.

Further in accordance with the Office Action of December 27, 2005, it is said therein that the combined teachings of Kojima and Ito fail to address a crucible with an inner diameter of 28 inches or more. However, Hoshi teaches a method pertaining to silicon crystal growth in which silicon crystals are grown from a

crucible having a diameter of 28 inches. Although such reference does not exclusively teach an inner diameter of 28 inches, Schupp is said to teach a heating arrangement for a crystal growth furnace where it is explicitly taught that the inside diameter of the crucible would need to have an inner diameter of 29 inches, which reads on 28 inches or more.

As applicant has previously pointed out, the discussion at line 18 of page 3 through line 3 of page 4 of the specification describes that by using a crucible of larger diameter, heating from the lateral direction only by the side heater 2 in an ordinary apparatus for producing a single crystal as shown in Fig. 3 of the application tends to become insufficient in terms of heating quantity. In particular, after the single crystal ingot is detached, the heat receiving area from the lateral direction is decreased because the melt becomes shallow. As a result, it is likely that a phenomenon of solidification of the melt frequently occurs. And, in the multi-pulling, when the raw material is occasionally introduced, a stress is applied to the crucible at the time of solidification, and the crucible may crack (see line 20 of page 20 through line 5 of page 21 of the specification).

In accordance with claim 4 of the present application, when a single crystal according to the Czochralski method is grown, the multi-pulling is performed by using a large diameter crucible having an inner diameter of 28 inches or more, the crucible is heated by the heater surrounding the crucible and the lower subsidiary heating means for a period from the point of the detachment of the single crystal ingot to the point of complete melting of the raw material in the crucible including the raw material newly added thereto. Further, the electric power supplied to the subsidiary heater is increased when the raw material is newly added thereto. In accordance with this method, the raw material can be introduced at a high introduction rate, and the crucible is prevented from being cracked by solidification of melt and from being deformed by excessively elevated temperature. Moreover, large single crystals can be obtained with a high yield (see line 21 of page 11

through line 19 of page 14, lines 6-26 of page 21, and elsewhere throughout the specification).

As set forth in Fig. 1(A), Fig. 3, claims 1 and 4, lines 42-51 of column 6, lines 12-14 of column 9, and elsewhere throughout Kojima, such reference discloses that when a silicon ingot is grown by a Cz method, heat is supplied by the side heater and the bottom heater during the second half of the growth process of the ingot. However, Kojima neither teaches nor suggests that the raw material is additionally charged in the crucible after a single crystal is pulled and another single crystal is continuously grown, namely, multi-pulling. Therefore, in Kojima, it is unlikely that the electric power supplied to the bottom heater is increased after a grown single crystal is detached from the melt, as recited in claim 4 of the present application. Moreover, in the Example of columns 13 and 14, Kojima discloses that a silicon single crystal having a diameter of 200 mm is grown by using a crucible having a diameter of 22 inches. However, Kojima does not describe or suggest a large diameter crucible having an inner diameter of 28 inches or more as recited in claim 4, for example. This is used, for example, in the case where a silicon single crystal having a diameter of 300 mm or more is grown. Furthermore, Kojima neither teaches nor suggests that the remaining melt is likely to solidify, in particular when such a crucible having a large diameter is used.

As described in the Abstract, Figs. 1 and 2, and elsewhere, Ito discloses that the raw materials 6 in a crucible 2 are melted rapidly and effectively by side heaters 3 and bottom heaters 4. However, such reference neither teaches nor suggests multi-pulling. Therefore, in Ito, it is also unlikely that the electric power supplied to the bottom heater is increased after a growing single crystal is detached from the melt. Moreover, as described at lines 9-11 in the upper right column on page 3 of Ito, polycrystal silicon of 50 kg charged in "the inner crucible made of quartz 2a having a diameter of 16 inches" was melted by the side heater 3 and bottom heater 4. However, Ito does not describe a crucible having a large diameter of 28 inches or more, as recited in claim 4 of the present application. Moreover, the reference

neither teaches nor suggests that the remaining melt is likely to solidify in particular when such a crucible having a large diameter is used.

At the bottom of page 3 of the Final Office Action, it is asserted that it would have been obvious to one of ordinary skill in the art at the time of the present invention to combine the raw material melting use of the bottom heater (Ito) with the growth use of the bottom heater (Kojima) because the turn-around time between uses of the apparatus would have been reduced and more product could have been made. Moreover, at the bottom of page 4 of the Final Office Action, the textbook of Sears et al. is referenced, and it is indicated that solid raw material must be supplied with the heat of fusion in addition to any heat required to raise its temperature if it is to be melted. However, as described above, Kojima and Ito neither teach nor suggest multi-pulling. Moreover, the Sears textbook only describes a general relationship between a phase change, namely from solid to liquid, for example from ice to water, and heat. Sears has no relationship to multi-pulling of silicon single crystals. Therefore, it is only with the hindsight provided by the present invention that Kojima and Ito are applied to multi-pulling.

Furthermore, even if multi-pulling is performed with the combination of Kojima and Ito, the method of claim 4 cannot be derived. Kojima and Ito neither teach nor suggest that the melt is likely to solidify when a crucible having a large diameter is used, and that a single crystal is grown by using a large diameter crucible having an inner diameter of 28 inches or more, as recited in claim 4 of this application. Therefore, even if the multi-pulling is performed with the combination of Kojima and Ito, at best, crystals having an ordinary diameter of 200 mm are only grown by using a crucible having a diameter of 22 inches described in the Example of Kojima.

On the other hand, and according to claim 4 of this application, the multi-pulling can be safely and certainly performed using a large diameter crucible having an inner diameter of 28 inches or more and subsidiary heating means (lower

heater), so that large silicon single crystals, for example, having a diameter of 300 mm or more, can be produced with high productivity.

As noted above, the newly cited references of Hoshi and Schupp are said in the Final Office Action to use a crucible having a diameter of 28 inches so that it would have been obvious to incorporate such teachings with the combined teachings of Kojima and Ito. Further according to the Office Action, there is no evidence supported by the present specification that the size of the crucible aided in the differentiation of the invention, indicating that the crucibles with 22 or 28 inches are essentially equivalent.

However, the object of Hoshi is to increase a growing rate of the single crystal. Such object is different from that of Kojima and Ito, so that Hoshi cannot be combined with Kojima and Ito.

Moreover, Hoshi, Kojima and Ito do not describe a problem with a crucible having a larger diameter (in particular, an inner diameter of 28 inches or more) that is solved by the present invention. Moreover, Hoshi, Kojima and Ito neither describe nor suggest the multi-pulling feature of the present invention. Consequently, the present invention cannot be derived from the combination of Hoshi, Kojima and Ito.

Schupp does not relate to a method for a single crystal by the Czochralski method, and has nothing to do with the present invention. Nor does such reference have anything to do with Hoshi, Kojima and Ito. Consequently, Schupp cannot be combined with Hoshi, Kojima or Ito.

Furthermore, the size of a crucible is a feature which distinguishes the present invention from the various references. The present invention is particularly effective in a case where a single crystal is grown by using a crucible having an inner diameter of 28 inches or more. In a case where the single crystal is grown by using the crucible having the increasingly larger inner diameter, the need for the

present invention becomes still greater (see line 17 of page 13 through line 6 of page 14 of the specification).

For the various reasons set forth above, claim 4 is submitted to clearly distinguish patentably over the cited references and the attempted combination thereof.

Claims 1-3 and 5 depend directly or indirectly from and contain all of the limitations of claim 4, so that such claims are also submitted to clearly distinguish patentably over the cited art.

(viii) CLAIM APPENDIX

1. The method for growing a semiconductor single crystal according to Claim 4, wherein the single crystal is pulled with subsidiarily heating the crucible by the subsidiary heating means in addition to the heating by the heater surrounding the crucible for a period after a ratio of a weight of the growing crystal during the pulling of the crystal relative to a weight of raw material melt before the growing becomes 60% or more.

2. The method for growing a semiconductor single crystal according to Claim 1, wherein the heating by the subsidiary heating means is performed so that temperature gradient of the single crystal surface along the pulling axis direction is constant.

3. The method for growing a semiconductor single crystal according to Claim 1, wherein electric power values of the heater surrounding the crucible and the subsidiary heating means and/or a ratio of the both power values are obtained by calculation based on global heat transfer analysis, the obtained value(s) is/are used as a target value or values of control, and electric powers supplied to the heater and the subsidiary heating means are controlled to approach the target value or values during the pulling of the single crystal.

4. A method for growing a semiconductor single crystal according to the Czochralski method utilizing an apparatus for producing a semiconductor single crystal having a crucible to be charged with a raw material, a heater surrounding the crucible, pulling means for bringing a seed crystal into contact with a melt contained in the crucible and growing a single crystal and a metal chamber for accommodating the foregoing members, wherein a crucible having an inner diameter of 28 inches or more is used and the apparatus is provided with subsidiary heating means below the crucible, and after a grown single crystal is detached from the melt and taken out from the apparatus for producing a crystal, a raw material is newly added to the raw material remained in the crucible and melted, and when a seed crystal is brought into contact with the melt to pull a single crystal again, the crucible is heated by the heater surrounding the crucible and the subsidiary heating means to prevent solidification of raw material melt at least for a period from the point of the detachment of the single crystal ingot to the point of complete melting of the raw material in the crucible including the raw material newly added thereto and the electric power supplied to the subsidiary heating means is increased when the raw material is newly added to the raw material melt remaining in the crucible.

5. The method for growing a semiconductor single crystal according to Claim 2, wherein electric power values of the heater surrounding the crucible and the subsidiary heating means and/or a ratio of the both power values are obtained by calculation based on global heat transfer analysis, the obtained value(s) is/are used as a target value or values of control, and electric powers supplied to the heater and the subsidiary heating means are controlled to approach the target value or values during the pulling of the single crystal.

(ix) EVIDENCE APPENDIX

None

(x) RELATED PROCEEDINGS APPENDIX

None

It is therefore respectfully requested that the Final Rejection of claims 1-5 be reversed, and that such claims be determined to be allowable.

This Appeal Brief is submitted herewith in triplicate, and the requisite brief fee is enclosed herewith.

If there are any fees in connection with the filing of this Appeal Brief, please charge the fees to our deposit account number 50-1314.

Respectfully submitted,

HOGAN & HARTSON L.L.P.

Date: May 1, 2006

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